

Physical and Electrochemical Properties of PEG Electrolyte Gels Prepared via Sol-Gel Condensation

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Recently, batteries have been especially required for superior electrical performance in response to the need for the miniature power supply for consumer applications [1-2]. Among them, lithium polymer batteries are now being widely studied and developed as rechargeable energy sources, the most important of which is for high energy density batteries [3]. The lithium polymer battery does not need safety device to prevent overcharge and can be fabricated into light and flexible shape, but it still poses the challenge of how close its electrical performance can be made to that of the liquid electrolyte battery. It must therefore meet the following requirements to be used in lithium polymer batteries: i) electrochemical stability not only towards metallic lithium but also towards cathode materials in order to avoid the increase of the interfacial resistance affecting the battery performance and shortens its lifetime, ii) high ionic conductivity at the operating temperatures of the battery, iii) high thermal stability, notably at temperatures above 200°C, iv) high mechanical stability in order to lower the electrolyte film thickness. For these reasons, many researches were conducted regarding the development of new polymer electrolyte [4].

Poly(ethylene glycol)(PEG) of low molecular weight has the advantage of having relatively high ambient ionic conductivity(10^{-4} S/cm), when complexed with alkali-metal salt. However, their poor mechanical strength cannot satisfy the requirement for solid-state processing.

In this study, low molecular weight PEG was cross-linked via sol-gel condensation with tetraoxyethyl siloxanes (TEOS) not only to attain high ionic conductivity by preventing the formation of crystalline structure but also to attain high mechanical strength even impregnated with electrolyte liquid. After impregnation of cross-linked PEG with electrolyte solution, thermal, mechanical, and electrochemical properties were investigated.

Fourier transform infrared spectroscopy (FTIR) was used to investigate the presence of cross-links (siloxane groups) in the synthesized polymer products as shown in Fig. 1. Differential scanning calorimetry (DSC) and X-ray diffractometry (XRD) were used to investigate the presence of crystalline structure.

The ionic conductivity was measured using Solartron 1255HF frequency response analyzer and Solartron 1286 electrochemical interface. Fig. 2 shows the relationship between the ionic conductivity and the salt concentration in the solid polymer electrolyte.

The temperature dependence of conductivity of these systems obeys the Arrhenius behavior. The curve of $\log_{10} \sigma$ vs $1/T$ as shown in Fig. 3 shows the temperature dependence of conductivity of PEG300/TEOS/LiClO₄ ([EO]/[Li] = 15).

References

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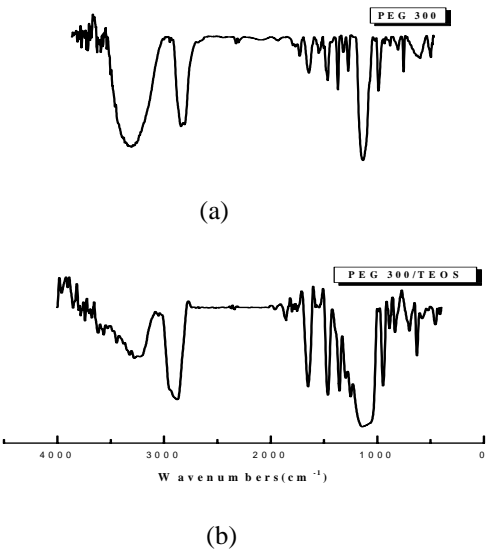


Fig. 1. FT-IR transmittance of PEG300(a) and PEG300/TEOS(b), respectively.

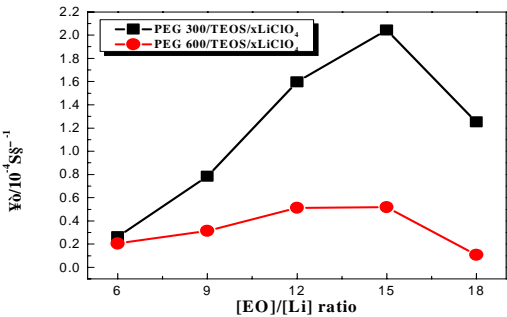


Fig. 2. Ionic conductivity of PEG300/TEOS/xLiClO₄ and PEG600/TEOS/xLiClO₄ electrolytes as a function of [EO]/[Li] ratio at room temperature.

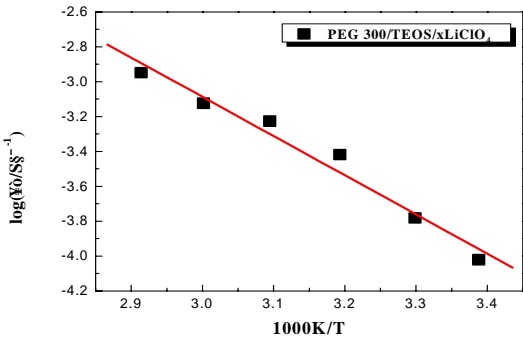


Fig. 3. The temperature dependence of ion conductivity of PEG300/TEOS/xLiClO₄ electrolyte.